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FRUIT MORPHOLOGICAL VARIABILITY IN DIFFERENT COMMERCIAL CULTIVARS AND LOCAL VARIETIES OF *ANANAS COMOSUS* (L.) MERR. FROM KERALA

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ABSTRACT

The pineapple, Ananas comosus (L.) Merr., is a perennial, herbaceous monocot of the family Bromeliaceae. Fruit morphological characters were studied in 17 accessions of A. comosus which include commercial cultivars and local varieties. Twenty three qualitative and nine quantitative traits of fruits were scored. The first principal component accounted for 96.79% of phenotypic variation followed by the second for 1.06 % of variation. Major traits that accounted for more variability in PC1, PC2 and PC3 include fruit shape, fruit colour when unripe, colour of crown attachment area and crown shape. The UPGMA clustering method revealed two principal clusters which separated all accessions between Euclidean distances 0.358-1.395. Both cluster analysis and principal co-ordinate analysis revealed that ACBR1 and ACBR2 (accessions of Ananas commosus var. bracteatus – red) are distantly placed among all other accessions. The most closely related cultivars are Amritha and Mauritius in the phenogram. Accessions of cultivar Kew are grouped together with MD2.

KEYWORDS: Ananas Comosus, Morphological Variability, Cultivar

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INTRODUCTION

Pineapple [*Ananas comosus* (L.) Merr.] is an important tropical fruit crop in terms of economic value and nutrition content. It belongs to the family Bromeliaceae (Bartholomew and Paull, 1986). It is widely cultivated in tropical and sub tropical countries. Pineapple is a unique fruit for its appearance, delicate fragrance and excellent flavour. Its fruit is consumed fresh and canned as a commercial product in many countries. Pineapple is an important source of sugars, organic acids and some essential minerals for human nutrition and its quality of good flavour, aroma, juiciness and sweetness is well known and appreciated by consumers (Hodgson and Hodgson,1994). *A. comosus* consists of different cultivars showing many variations (Leal and Soule, 1977). The terminal inflorescence develop into a multiple fruit or sorose composed of 50-200 fruitlets. The edible part of the fruit mainly consists of the ovaries, the bases of the sepals and bracts, and the cortex of the axis (Purseglove, 1972 and Bartholomew et al., 2003). The fruit shell is primarily composed of sepal and bract tissues and the apices of the ovaries (Okimoto 1948). Pineapple shows both inter and intra varietal diversity in different qualitative and quantitative fruit morphological characters.

The four major commercial cultivars in Kerala are Mauritius, Kew, MD2 and Amritha. In addition to this, small scale cultivations of different local varieties are present in home yards. These commercial cultivars and local

varieties show lot of variations in fruit morphological characters. Analysis of morphological characters is a classical approach to differentiate plant cultivars. The significance of morphological traits for the characterization of pineapple cultivars were studied (Valencia and Alcasid, 2014). The importance of pomological characters to identify the local and cultivated orange cultivars was reported (Debbabi et al., 2013). The morphological variation in fruit of sweet chestnut for genetic diversity studies was reported (Atefe et al, 2015). The present study aims at analyzing the fruit morphological variations in different cultivars and local varieties of *Ananas comosus* from Kerala. Also it is targeted to evaluate the reliability of the fruit morphological characters and their relevance for the identification of particular varieties.

MATERIALS AND METHODS

In the present study, different accessions of the four commercial cultivars and two local varieties of pineapple were collected from different localities of Kerala and maintained in the experimental field, located at the Department of Botany, University of Kerala, Kariavattom, Thiruvananthapuram. The collections consist of seven accessions of *Ananas comosus* var. *comosus* cv. Mauritius, four accessions of *Ananas comosus* var. *comosus* cv. Kew, one accession of *Ananas comosus* var. *comosus* cv. MD 2, one accession of *Ananas comosus* var. *comosus* cv. Amritha, two accessions of *Ananas comosus* var. *bracteatus*- red and two accessions of *Ananas comosus* var. *bracteatus*- green. Specific codes were allotted to each accession (Table 1). The voucher specimens of these accessions are deposited in the herbarium of the Department of Botany, University of Kerala.

Observations on 23 qualitative traits (Table 2) and nine quantitative traits of fruits were scored in all accessions, based on the descriptors developed by International Board for Plant Genetic Resources (IBPGR, Rome) for Pineapple. The quantitative traits recorded are the following; fruit weight (FRW), fruit height (FRH), fruit diameter (FRD), number of fruitlets (NFLTS), eye number (EN), number of right pointing spirals (NRPS), number of left pointing spirals (NLPS), eye number in the longest spiral (ENLS) and number of fruit basal slips (NFBSLPS).

The data on both qualitative and quantitative traits were recorded on ten fruits in each accession. In morphometric analysis, one way ANOVA and Duncan multiple range test were performed. Multivariate analysis was performed by numeric taxonomic techniques using the procedure of principal component analysis. To bring out the patterns of similarity and dissimilarity, data was subjected to cluster analysis based on UPGMA method to group the 17 accessions. Principal co ordinate analysis (PCoA) followed by construction of scatter plots was also performed. SPSS version 16 and Multivariate statistical package MVSP Version 3.1 were used for statistical analysis.

RESULTS

Analysis of Variance

Analysis of variance carried out on different quantitative data showed significant variation (p <0.05) among the 17 accessions studied (Table 3). Fruit weight was significantly (p<0.05) high in ACBR1 followed by ACK1 and low in ACM4. But fruit height was high in ACM4 and low in ACBR2. Regarding the fruit diameter, ACK2 and ACBG1 showed the highest average while ACBG2 showed the lowest average. Number of fruitlets, Eye number and number of right pointing spirals are significantly high in ACM1. But these characters showed the lowest average in ACBR2. Considering the number of left pointing spirals, ACK3 showed the highest value. ACM7 showed the highest eye number in the longest spiral. In the case of number of fruit basal slips, it showed the highest average in ACBG 1. Fruit basal slips are completely absent in all accessions of cultivar Kew and MD2.

Principal Component Analysis

In principal component analysis, the first principal component accounted maximum variation (96.79%). The first principal component had traits with highest loadings are fruit height, fruit diameter, number of fruitlets, eye number, number of right pointing spirals, number of left pointing spirals, eye number in the longest spiral, fruit shape, fruit colour when unripe, fruit colour when unripe, fruit colour after ripening, colour of crown attachment area, crown shape, flesh colour and flesh fibrousness.

The second principal component accounted for 1.06% of variation with highest loadings are fruit shape, fruitlet shape, fruit colour when unripe, eye profile, orientation of the longest spiral, fruit external aroma, crown attachment, colour of crown attachment area, crown shape, attitude of crown foliage, flesh colour, flesh fibrousness, flesh aroma, seediness and eye depth. The third principal component accounted for 0.79% of variation with number of fruit basal slips, fruit shape, crown attachment, crown shape, attitude of crown foliage, seediness are the characters which shows dominance in variability. Major traits that accounted for more variability in PC1, PC2 and PC3 include fruit shape, fruit colour when unripe, colour of crown attachment area and crown shape. The highest loaded variables in PC1, PC2 and PC3 were number of fruit lets (0.472), eye number (0.472), fruit shape (0.319) and seediness (0.384). Hence fruit characters are important in distinguishing various accessions of *A. comosus*.

Cluster Analysis

UPGMA cluster analysis with 32 variables revealed two principal clusters which separated all the accessions at a Euclidean distance of 1.395(Figure 1). In the first principal cluster, the morphotypes of *A. comosus* var. *bracteatus* – red (ACBR1 and ACBR2) are clustered together at a distance of 0.819. These were the most distantly placed among all the accessions.

The second principal cluster consists of three groups, the first group consists of ACBG1 and ACBG2, they are clustered together at a distance of 0.358. The second group was the largest with eight accessions. It consists of ACM2, ACM1, ACM6, ACM7, ACA1, ACM5, ACM3 and ACM4. They are clustered together due to the presence of projected fruit lets, good fruit colour homogeneity after ripening, presence of spines on the margins of the crown leaves, flesh fibrousness and deep eye. In this phenogram the more closely related cultivars are ACM2, ACM1, ACM6, ACM7 and ACAI (Euclidean distance 0.927) due to the presence of long conical crown.

In the third group, ACMD1, ACK1, ACK4, ACK2 and ACK3 are clustered together at a distance of 0.999 due to the presence of broad fruit lets, medium fruit colour homogeneity after ripening, presence of spines only at the tip of crown leaves, intermediate amount of flesh fibres and medium flesh aroma. But ACMD1 is distinct from other four accessions in having small eye profile, absence of external aroma, crown attachment to the fruit with short distinct neck, oblong blocky crown shape and shallow eye depth.

Principal co- ordinate Analysis (PCoA)

In PCoA, the ACBR1 and ACBR2 (accessions of *Ananas comosus* var. *bracteatus-red*) are the most distantly placed among all other accessions. The accessions of cultivar Mauritius showed close association with cultivar Amritha and accessions of cultivar Kew showed close association with MD2. Hence the principal co- ordinate analysis supports the results of cluster analysis.

DISCUSSIONS

The present study helps to identify the pineapple cultivars in Kerala. The analysis of morphological characteristics in pineapple is employed to differentiate cultivars and selection of parents for conventional hybridization for desirable traits. Debbabi et al (2013), Zaouay and Mars (2011) reported the importance of the pomological characteristics to assess genetic diversity and cultivar relationships among Citrus cultivars and identification of pomegranate accessions respectively.

The cluster and principal component analysis on fruit morphological characters revealed the existence of variability among the different accessions of pineapple cultivars. Based on PCA, it is clear that the percentage of variation was very high, suggesting that the fruit morphological characters studied were efficient for pineapple cultivar characterization. Similar studies were reported in characterization of local germ plasm of Figure (Saddoud et al., 2008) and Olive tree (Hennachi et al, 2008). In PC1, the external fruit morphological characters such as fruit height, fruit diameter, number of fruit lets, eye number, number of right pointing spirals, number of left pointing spirals, eye number in the longest spiral, fruit shape, fruit colour when unripe, fruit colour when unripe, fruit colour after ripening showed high variability than the crown characters. At the same time crown characters are also highlighted in PC2. Valencia and Alcasid (2014) reported the importance of fruit morphological characters in identification of pineapple cultivars. De Souza et al (2012) also reported the significance of morphological characters for the identification and classification of pineapple with ornamental potential.

CONCLUSIONS

Fruit morphological analysis of different pineapple cultivars and local varieties showed diversity within the germ plasm. This analysis is very useful for its collection, cultivation and use in future crop improvement programmes such as selection and hybridization. Only the fruit morphological characters are not enough to identify pineapple cultivars. So the biochemical as well as molecular markers are required to evaluate the variability among the cultivars.

Table 1: Details of Collection of *Ananas comosus* from Various Localities

Sl. No.	Accession Code	Accession Name	Genetic Group
1	ACM1	Chadayamangalam	*Ananas comosus* cv. Mauritius
2	ACM2	Vazhakkulam	*A. comosus* cv. Mauritius
3	ACM3	Mannuthy	*A. comosus* cv. Mauritius
4	ACM4	Kanjar	*A.comosus* cv. Mauritius
5	ACM5	Thiruvampady	*A.comosus* cv. Mauritius
6	ACM6	Thiruvalla	*A. comosus* cv. Mauritius
7	ACM7	Puthezham	*A. comosus* cv. Mauritius
8	ACK1	Chadayamangalam	*A. comosus* cv. Kew
9	ACK2	Vazhakkulam	*A.comosus* cv. Kew
10	ACK3	Mannuthy	*A. comosus* cv. Kew
11	ACK4	Seethathode	*A. comosus* cv. Kew
12	ACMD1	Vazhakkulam	*A. comosus* cv. MD 2
13	ACA1	Mannuthy	*A. comosus* cv. Amritha
14	ACBR1	Kottarakkara	*A.comosus* var. *bracteatus*- red
15	ACBR2	Kollam	*A. comosus* var. *bracteatus*- red
16	ACBG1	Kottarakkara	*A. comosus* var. *bracteatus*- green
17	ACBG2	Ayur	*A. comosus* var. *bracteatu*- green

Table 2: List of Qualitative Variables Evaluated for the Study of Fruit Morphological Variability in *A. comosus*

Ref. No.	Character Description	Descriptor States
1.	Fruit shape	0-square like, 1-oval, 2-round, 3-conical, 4-long conical, 5-pyramidal, 6- cylindrical slight tapers, 7- cylindrical sharp tapers, 8-pyriform, 9-reniform, 10-oblong.
2.	Type of fruit	0-Grouped fruitlets, 1-isolated fruits.
3.	Fruitlet shape	0-shallow, 1-broad, 2-projected.
4.	Fruit colour when unripe	0-silvery green, 1- green, 2- dark green, 3-dark blackish green, 4-light green, 5-orange red, 6- red, 7- pink, 8-red purplish, 9- dark red purple, 10-purple, 11-purple blue.
5.	Fruit colour when ripe	0-Green, 1- silvery green, 2- yellow with green mottling, 3- dull yellow, 4-bright yellow, 5- golden yellow, 6- deep yellow to orange, 7- reddish orange, 8- brownish.
6.	Fruit colour homogeneity when ripe	0-poor, 1- medium, 2-good
7.	Eye profile	0-flat, 1-normal, 2- prominent
8.	Eye relative surface	0-small, 1-medium,2-large
9.	Orientation of the longest spiral	0-left, 1-right, 2-vertical.
10.	Fruit external aroma	0-absent, 1-mild, 2-pleasant, 3- excellent.
11.	Presence of crown	0-absent, 1- present.
12.	Crown attachment	0-with sessile neck, 1-with short distinct neck.
13.	Colour of crown attachment area	0-yellow, 1- silvery green, 2-green, 3-dark green, 4- green with orange mottling, 5-silvery green with red mottling, 6-light orange, 7-light or dark red, 8- pink,9-red purplish.
14.	Crown shape	0-cone,1-oblong blocky, 2- acron, 3-long conical, 4- lengthened cylindrical, 5- lengthened cylindrical with bunchy top, 6- other.
15.	Attitude of crown foliage	0-erect, 1-semi erect, 2- horizontal, 3-drooping.
16.	Colour of crown leaves	0-green, 1- green with yellow mottling, 2- silvery green with red mottling, 3- reddish orange, 4-reddish green, 5- dark red, 6-pinkish, 7-pink, 8-silvery white,9- silvery green.
17.	Presence of spines on crown leaves	0-smooth, 1- spines at the tip, 2- spiny serrate, 3- piping.
18.	Crown character	0-normal, 1-multiple, 2-single with crown lets.
19.	Flesh colour	0-white,1-light cream, 2-cream, 3-pale yellow, 4-yellow, 5-golden yellow, 6-deep golden yellow, 7-light orange, 8-deep orange, 9-other.
20.	Flesh fibrousness	0-almost non fibrous, 1- small amount of fibre, 2-intermediate amount of fibre,3- fibrous.
21.	Flesh aroma	0-hardly any aroma,1- medium aroma, 2- rich aroma
22.	Seediness	0-no seeds, 1-few, 2- medium, 3-very seedy
23.	Eye depth	0-shallow,1- medium, 2-deep.

Table 3: Quantitative Fruit Morphological Characters of Different Accessions of *A. comosus*

Accessions	Fruit Weight (Kg)	Fruit Height (cm)	Fruit Diameter (cm)	No. of Fruit Lets	Eye No.	No. of Right Pointing Spiral	No. of Left Pointing Spiral	Eye no. in the Longest Spiral	No. of Fruit Basal Slips
ACM 1	1.0972 ±0.083	15.8±0.464	10.2±0.41	136.4±3.54	136.4±3.54	13.2±0.2	8±0.0	17.4±0.245	0
ACM 2	1.1544±0.12	16±1.36	10.1±0.29	113.4±5.99	113.4±5.99	11±0.55	8.4±0.245	15±0.45	1±0.45
ACM 3	1.03 ± 0.14	12.1±0.332	10.1±0.43	114.8±6.26	114.8±6.26	11.6±0.51	8.2±0.2	11.4±0.81	0.4±0.245
ACM 4	0.8124±0.06	14.4±0.731	10.1±0.292	133±6.83	133±6.83	10.2±0.37	7.8±0.2	16.6±0.51	0
ACM 5	0.854±0.098	11.9±0.4	10.3±0.3	116±3.85	116±3.85	11.4±0.245	7.4±0.245	16.2±0.58	0.4±0.245
ACM 6	0.91±0.04	12.6±0.19	9.98±0.15	113±2.811	113±2.81	8.2±0.2	13±0.0	13±0.32	0
ACM 7	1.156±0.056	19.2±0.464	10.8±0.09	192±11.95	192±11.95	12.8±0.2	8.2±0.2	22.8±0.37	0
ACK 1	1.3630±0.21	12.98±0.892	10.9±0.263	100±13.842	100±13.842	11.8±0.374	8±0.0	12.8±1.32	0
ACK 2	1.13±0.095	12.4±0.696	11.1±0.4	67±3.899	67±3.899	7.8±0.2	12.4±0.4	9.6±0.51	0
ACK 3	1.282±0.0223	14.8±0.374	10.86±0.098	112.8±4.223	112.8±4.223	7.8±0.2	12.6±0.245	14.6±0.68	0
ACK 4	1.09±0.040	10.7±0.31	9.66±0.103	98±4.111	98±4.111	7.4±0.245	11.8±0.2	12.8±0.374	0
ACMD1	1.124±0.18	13.86±0.774	11±0.37	88.2±4.59	88.2±4.59	8.8±0.374	11.4±0.51	11.8±0.49	0
ACA1	1.215±0.12	16.56±0.89	11±0.16	119±12.613	119±12.613	12.8±0.2	8±0.0	18.2±2.06	1.8±0.49
ACBR1	1.48±0.065	15.5±0.354	10.46±0.25	111.6±3.54	111.6±3.54	12.2±0.374	7.4±0.4	13.2±0.37	1.6±0.51
ACBR2	0.899±0.02	10.6±0.103	9.5±0.032	62±1.924	62±1.924	5±0.0	7.6±0.245	12±0.0	0
ACBG1	1.284±0.029	17.92±0.177	11.1±0.38	109.4±4.44	109.4±4.44	12.6±0.245	7.4±0.245	13.2±0.374	5.4±1.25
ACBG2	1.112±0.03	14.8±0.255	9.26±0.103	91.4±1.78	91.4±1.78	11.6±0.245	7.8±0.2	12.4±0.245	2.2±0.66

Table 4: Principal Component Analysis in 17 Accessions of *A. comosus*, Eigen Values, Eigen Vectors and Percent of Variation Accounted by the First Three Principal Components (Highly Loaded Variables in Combined Analysis Given and Significant PC Values Indicated in Bold Face)

Variables	PC1	PC2	PC3
FRW	0.075	-0.06	0.004
FRH	**0.273**	-0.045	0.045
FRD	**0.245**	-0.062	-0.042
NFLTS	**0.472**	0.021	-0.05
EN	**0.472**	0.022	-0.05
NRPS	**0.243**	0.036	0.079
NLPS	**0.231**	-0.084	**-0.144**
ENLS	**0.273**	0.009	-0.025
NFBSLPS	0.038	-0.052	**0.557**
FRS	**0.171**	**0.319**	**0.364**
FRLS	0.081	**0.17**	**-0.25**
FRCU	**0.101**	**-0.422**	**-0.199**
FRCR	**0.184**	-0.083	**-0.112**
FCHR	0.099	0.043	0.095
EP	0.083	**0.14**	-0.029
ERS	0.07	-0.018	-0.01
OLS	0.024	**-0.144**	**-0.186**
FEA	0.093	**0.236**	-0.017
CA	0.037	**0.151**	**0.196**
CCA	**0.139**	**-0.241**	**-0.128**
CS	**0.12**	**-0.481**	**0.202**
ACF	0.046	**-0.281**	**0.227**
CCL	0.042	-0.008	0.032
PS	0.099	0.043	0.095
FC	**0.154**	**0.144**	0.056
FFB	**0.123**	**0.154**	0.058
FA	0.079	**0.269**	-0.056
SD	0.025	**-0.165**	**0.384**
ED	0.083	**0.144**	0.008

Table 4: Contd.,			
Eigen values	19.751	0.215	0.161
Percent variation	96.79	1.06	0.79
Cumulative percentage	96.79	97.84	98.63

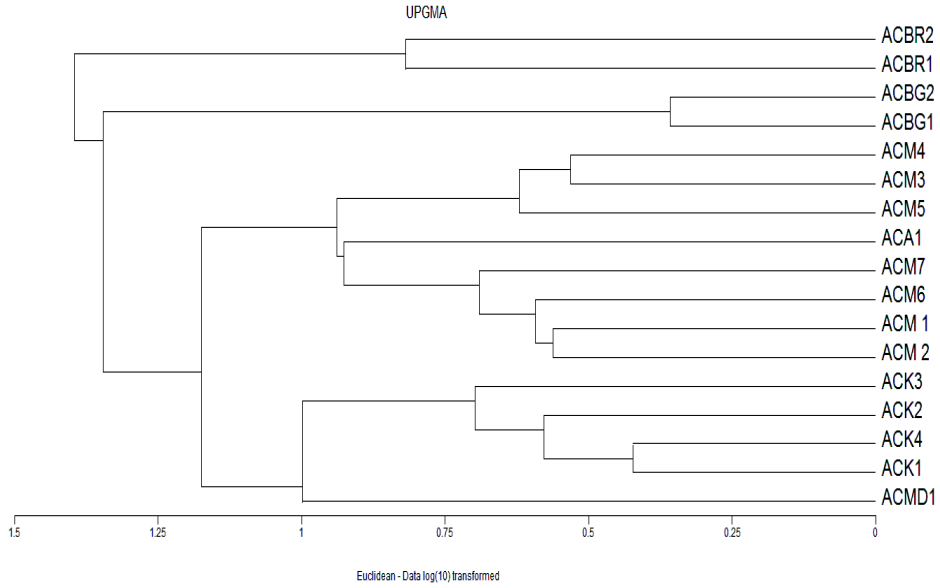

Figure 1: UPGMA Phenogram Based on Qualitative and Quantitative Characters

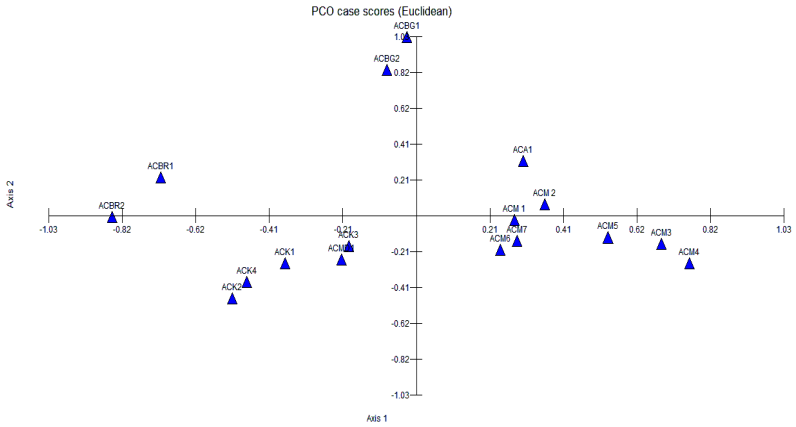

Figure 2: PCoA Based on Qualitative and Quantitative Characters

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